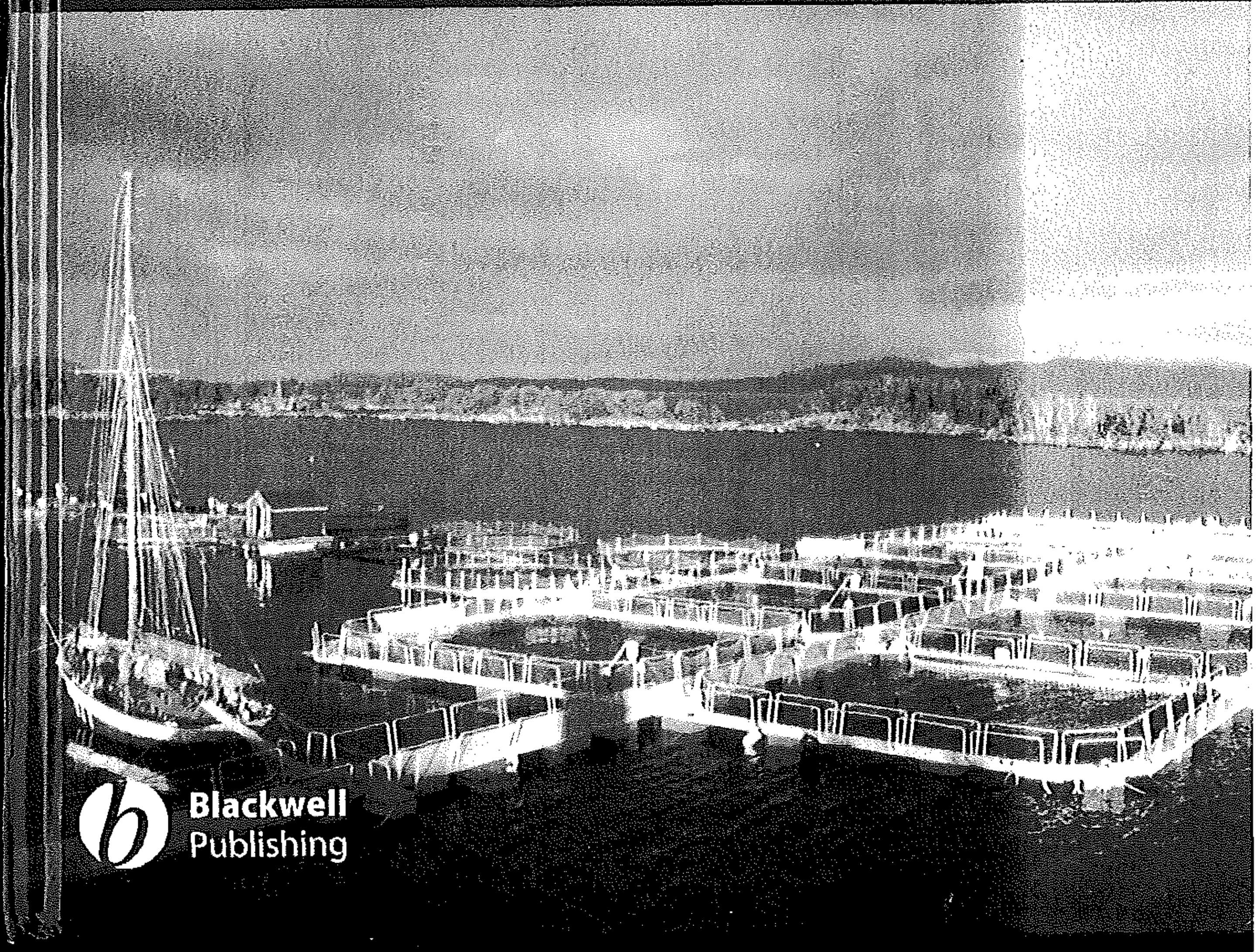
Aquaculture
Principles and Practices

SECOND EDITION

T.V.R. Pillay & M.N. Kutty



Blackwell Publishing

AQUACULTURE

PRINCIPLES AND PRACTICES

SECOND EDITION

T. V. R. PILLAY

Former Programme Director
Aquaculture Development and Coordination Programme
Food and Agriculture Organization of the United Nations
Rome, Italy

and

M. N. KUTTY

Former FAO/NACA Aquacultural Expert and
Former Dean and Professor of Fisheries
Tamil Nadu Agricultural University
Tamil Nadu, India

Blackwell Publishing

Editorial Offices:
Blackwell Publishing Ltd, 9600 Garsington Road, Oxford OX4 2DQ, UK
Tel: +44 (0)1865 776868
Blackwell Publishing Professional, 2121 State Avenue, Ames, Iowa 50014-8300, USA
Tel: +1 515 292 0140
Blackwell Publishing Asia Pty Ltd, 550 Swanston Street, Carlton, Victoria 3053, Australia
Tel: +61 (0)3 8359 1011

First Edition published 1990 by Fishing News Books, an imprint of Blackwell Science Ltd
Reissued in paperback 1993
Reprinted 1995, 1996, 1999, 2001
Second Edition published 2005 by Blackwell Publishing Ltd

Library of Congress Cataloging-in-Publication Data is available

ISBN 978-1-4051-0532-3

A catalogue record for this title is available from the British Library

For further information on Blackwell Publishing, visit our website:
www.blackwellpublishing.com

9.1.1 Factors affecting fish health

Fish health or the health of aquaculture organisms has to be conceived as a state of physical well-being. The importance of proper nutrition for rapid growth and the prevention of nutritional deficiencies have been discussed in Chapter 7. Adequate nutrition is also vital for the overall health and vigor needed to cope with a variety of disease agents. Nutritional deficiency symptoms associated with vitamin imbalances are well documented (see Table 7.7). However, imbalances in vitamin content of fish diets are not the only causes of nutritional diseases. Thyroid tumours, liver degeneration, visceral granuloma, anaemia and pigmentation impairment can be caused by other forms of nutritional imbalances. High levels of starch may give rise to symptoms of diabetes in trout and enlarged liver in channel catfish. Freedom from disease is an essential element of physical well-being, but physical and environmental stress have also significant roles in the maintenance of healthy conditions. Many of the potential pathogens of aquaculture species are normally found in the aquatic environment, but in spite of their presence disease may not occur. Obviously, disease is essentially the result of interaction between the species, the disease agent and the environment. So the three major factors of significance are the susceptibility of the species to the pathogens present, the virulence of the pathogenic agent and the environmental conditions that may trigger epizootics. Despite the individual importance of each one of these factors in the maintenance of good health or avoidance of disease, it should be emphasized that it is the balance between these factors that determines the state of health. Even in the presence of all three factors, the interaction may be such that no disease occurs. But a disturbance in any of the factors, leading to disruption of the relationship, can give rise to disease.

Susceptibility of the host

The susceptibility or the resistance of the culture species to the action of the disease agent is governed by its physical barriers, its exposure experience and its age. Among the physical barriers are the skin, scales, exoskeleton or shells and mucous membranes which limit the entry of toxic, infectious and parasitic agents. The physiological defences that keep the body from being overrun include the white blood cells that engulf pathogens, avoidance mechanisms, detoxification of chemicals from water or diet by the liver, storage of certain metals by the bones and local tissue reactions. The overall nutritional well-being is the source of the host's physiological ability to defend itself. The immune system and its specific activity against biological agents such as viruses, bacteria and parasites forms an important means of disease resistance. Populations with previous exposure to specific disease agents will generally not be as readily susceptible as those on a first encounter. For this reason and also because of the fragility of their defence system, young ones are more susceptible to diseases than older ones, except that the spawners may experience additional stress because of their reproductive functions. The species specificity of certain disease agents is also a factor of importance in understanding health hazards.

Once the pathogen has established itself within or on the host under favourable condition, the infection may take one of three routes:

(1) the pathogen proliferates, eventually causing mortality of the host;
(2) the defences of the host surmount the infection and eliminate the pathogen from its system; or
(3) a carrier state develops, whereby a balance between the host and the pathogen may persist generally, with no evident disease symptoms.

From an aquaculture point of view, the greatest concern is the rapid multiplication of the pathogen within the host and the danger of transfer to other individuals of the host population, which may result in an uncontrollable epizootic. During the incubation period (which is the interval between the penetration or establishment of the pathogen in the host and the appearance of the first symptoms of the disease), the host will often be shedding the pathogen. If the host recovers after this initial stage, or after any of the later stages of the infection, without entirely eliminating the pathogen, a carrier condition exists. A carrier order to increase the probability of survival of the host, some of the resulting metabolic changes contribute also to increased susceptibility to infection.

Of the physical factors, temperature is one that has an effect on a number of other variables in the environment. Temperatures above or below the tolerance limits of the host animal create stress. Increased metabolic rate caused by high temperature results in higher oxygen demand. However, dissolved gases, including oxygen, generally decrease in solubility with increasing temperature. Also the solubility of toxic compounds increases with increasing temperature, creating unfavourable conditions.

As well as the environmental effect on the host, the effect of temperature on the pathogen is also an important factor to be considered. For example, a rise in temperature generally accelerates to a certain limit all the biological processes of the causative agent, lowering its viability and sometimes causing its death. Similarly, lowering of temperature decreases the biological processes to a certain minimum below which the organism may not survive. Pathogenic organisms of the same genus in the same host may react differently to a change in temperature.

The minimum water quality conditions necessary to maintain fish health are:

dissolved oxygen	5 ppm
pH range	6.7–8.6 (extremes 6.0–9.0)
free total CO_2	3 ppm or less
ammonia	0.02 ppm or less
alkalinity	at least 20 ppm (as $CaCO_3$)

Obviously there are differences in the tolerance limits of different species, but these values provide a general guideline. Levels of tolerance of other elements are chlorine: 0.003 ppm; hydrogen sulphide: 0.001 ppm; nitrite (NO_2): 100 ppb in soft water, 200 ppb in hard water; and total suspended and settleable solids: 80 ppm or less.

Pesticide pollution is one of the common causes of environmental stress in aquaculture situations. The maximum pesticide concentrations that may be tolerated by fish, without noticeable effects, and recognized by the Environmental Protection Agency of the USA, are listed in Table 9.1.

Table 9.1 Maximum permissible pesticide concentrations which may be tolerated by fish.

Pesticide	Concentration
Organochlorine pesticides	
Aldrin	0.01
DDT	0.003
Dieldrin	0.005
Chlordane	0.004
Endrin	0.003
Lindane	0.02
Toxaphene	0.01
Organophosphate insecticides	
Diazinon	0.002
Dursban	0.001
Malathion	0.008
Parathion	0.001
TEPP	0.3
Carbamate insecticides	
Caebaryl	0.02
Zectran	0.1
Herbicides, fungicides and defoliants	
Aminotriazole	300.0
Diquat	0.5
Diuron	1.5
2,4-D	4.0
Silvex	2.0
Simazine	10.0
Botanicals	
Pyrethrum	0.01
Rotenone	10.0

Even though it is not a hazard to the aquaculture species itself, the development of off-flavour is a phenomenon that seriously affects the economics of culture. The earthy or musty taste of fish grown in affected ponds would make them unmarketable. The cause of off-flavour is reported to be a compound called geosmin produced by actinomycetes and a number of blue-green algae of the genus *Oscillatoria* (such as *O. princeps*, *O. agardhi*, *O. tenuis*, *O. prolifica*, *O. limosa*, and *O. muscorum*). All these organisms grow on mud that is high in organic matter. The organic matter decomposes, causing the reduction of the mud. These organisms grow well on the interface between the reduced mud and the oxidized water layer above it. The off-flavour generally disappears when the fish are held in clean water (preferably running water) for one to two weeks.

sets in and the colour turns yellow-brown. Secondary infection of *Saprolegnia* often occurs at this time.

To prevent the infection, dense stocking of rearing facilities should be avoided, particularly during warm weather. High concentrations of organic matter in the water supply should be avoided, and clean fresh water should be provided as often as possible. Recommended curative treatment in ponds is 200 kg finely ground quicklime per hectare of pond area, maintaining pH below 9. Copper sulphate may be used at the rate of 8 kg per hectare of ponds of about 1 m depth. This may be applied in four monthly instalments of 2 or 3 kg each. Benzalkonium chloride also can be used in one-hour baths at a concentration of 1–4 ppm. It is reported that baths of copper sulphate (1 g in 10 litres water) for 10–30 minutes will kill all the pathogens.

9.2.4 Protozoan diseases

Numerous protozoan parasites live on fish and other aquaculture species and cause both external and internal diseases, with serious mortalities in hatcheries and rearing facilities. Even moderate numbers of these organisms on small fish may prove fatal since the infections may cause the fish to stop feeding. Except in certain cases, the infected fish may die without showing any disease symptoms other than debilitation.

Ichthyophthiriasis (Ich)

Ichthyophthiriasis, caused by the protozoan parasite *Ichthyophthirius multifiliis* (fig. 9.16), is considered to be one of the most detrimental diseases in pond culture of fresh- and brackish-water fish. All species of pond-cultured fish,

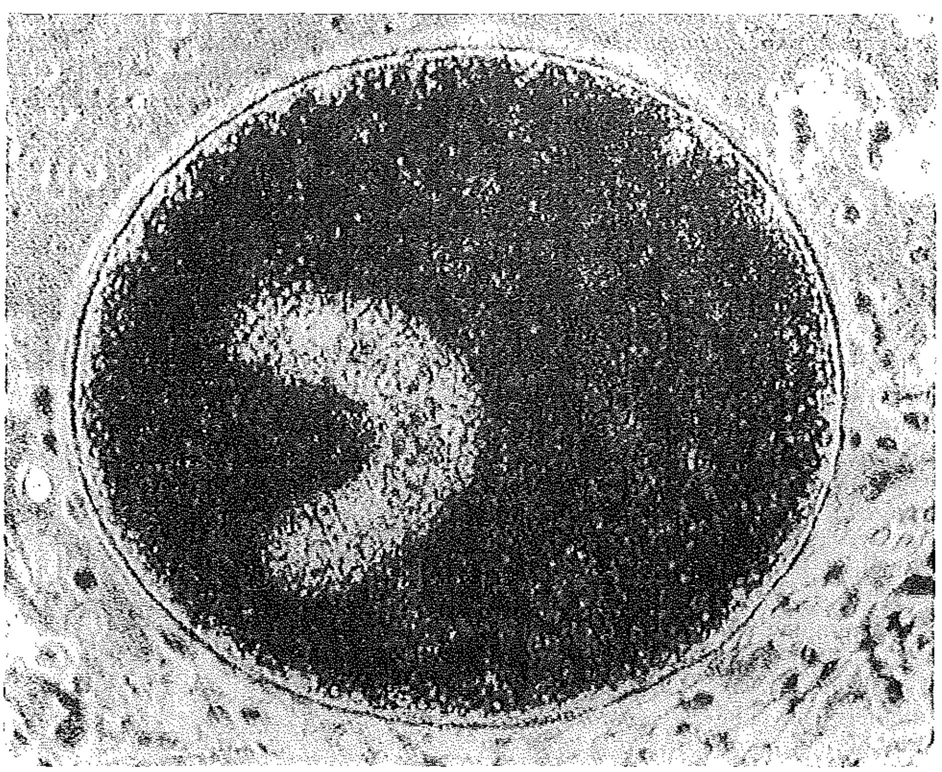


Fig. 9.16 *Ichthyopthirius multifiliis*, the causal agent of ich, under microscope. (Courtesy of Nikola Fijan.)

including common carp, Chinese carp and trout, are susceptible to the disease. *I. multifiliis* has a round or ovoid body (0.5–1.0 mm long) with a small rounded mouth. Longitudinal rows of cilia can be found on the surface of the body, converging at the anterior end. The large macronucleus is horseshoe-shaped and has numerous contractile vacuoles. This species multiplies on fish by repeated binary fission. The mature parasites (trophonts) break the white epithelial tubercle that covers them and enter the water. They settle at the bottom and attach themselves to submerged objects. On attachment, the parasite becomes enclosed in a gelatinous cyst and multiplies. One trophont divides into as many as 2000 ciliated bodies. They emerge into the water by dissolving the cyst which encloses them, with the enzyme hyaluronidase. They swim free for two to three days and if a host is found during that period, they penetrate under the skin, grow and mature. If they do not find a host, they will die. The optimal temperature for development is 25°–26°C. Outbreaks of the disease usually occur in spring and summer at high water temperature and under conditions of overcrowding that facilitate the spread of the disease. In light infections, the fish show restlessness and gather in groups near the water inlet. In heavy infections in yearlings, more severe symptoms can be noticed, including acute restlessness, the fish rubbing against the bottom and sides and collecting in masses near the inlet. Small tubercles occur on the body and the fish stop feeding and cease reacting to stimuli. In advanced cases, the fish swim at the surface and rush around swallowing air. Small white tubercles cover the entire body, and severe lesions of the cornea and blindness may also occur.

The fact that the non-parasitic stages of *Ichthyophthirius* are very sensitive to environmental factors makes it somewhat easier to prevent infection. The destruction of carrier fish is an essential aspect of prevention. Disinfection of contaminated water or equipment is recommended. Even dilute solutions of salt (0.5 per cent) will kill encysted parasites and the ciliated bodies. The ciliated bodies can also be killed by drying the ponds or other rearing facilities. A pH below 5 and oxygen concentrations of less than 0.8 mg/l are reported to be fatal. Even though vaccines are not available for immunization of fish against ich, repeated infections apparently provide relative immunity. In ponds, treatment with 0.1 ppm malachite green or 15 ppm formalin once, twice or three times, has been reported to be effective.

Ichtyobodosis

Ichtyobodosis, previously known as costiasis, is a severe disease affecting many species of fish, including common carp and trout, especially the younger age groups. It is caused by the flagellate *Ichtyobodo necator* (*Costia necatrix*) (fig. 9.17). The parasite attaches itself to the skin of the host. Its anterior end forms finger-shaped processes at the point of attachment, which penetrate into the cell of the host and suck its contents. The parasite multiplies by longitudinal division and dies when it falls from the host. Transmission takes place through water. Under adverse conditions, the body of the parasite becomes rounded.

It can live at temperatures ranging from 2 to 30°C or higher, but multiplies rapidly at 20–25°C. A pH of 4.5–5.5 is very favourable for mass reproduction. In carp farms, ichtyobodosis occurs frequently in spawning ponds at higher temperatures. The incidence of the disease decreases rapidly when the young fish are transferred to rearing ponds.

A characteristic symptom of the disease is the appearance of dull spots on the sides, which eventually become fused into a continuous grayish film by the increased secretion of mucus. The fins are frequently affected, starting with erosion of the tissue between the rays, which becomes exposed. The fry becomes ema-

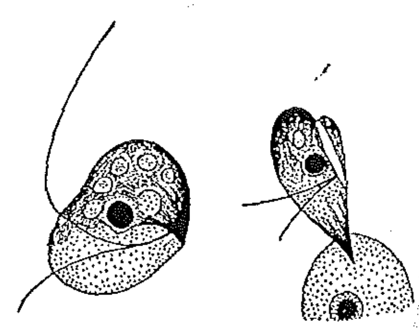


Fig. 9.17 *Costia necatrix*. (From Bauer *et al.*, 1973.)